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ABSTRACT

This student module on fire prevention and emergency procedures is one of 50 modules concerned with job safety and health. This module discusses the chemistry of fire and the methods for extinguishment, along with the steps necessary for emergency action. Following the introduction, 10 objectives (each keyed to a page in the text) the student is expected to accomplish are listed (e.g., List the basic requirements for an emergency action plan). Then each objective is taught in detail, sometimes accompanied by illustrations. Learning activities are included. A list of references and answers to learning activities complete the module. (CT)

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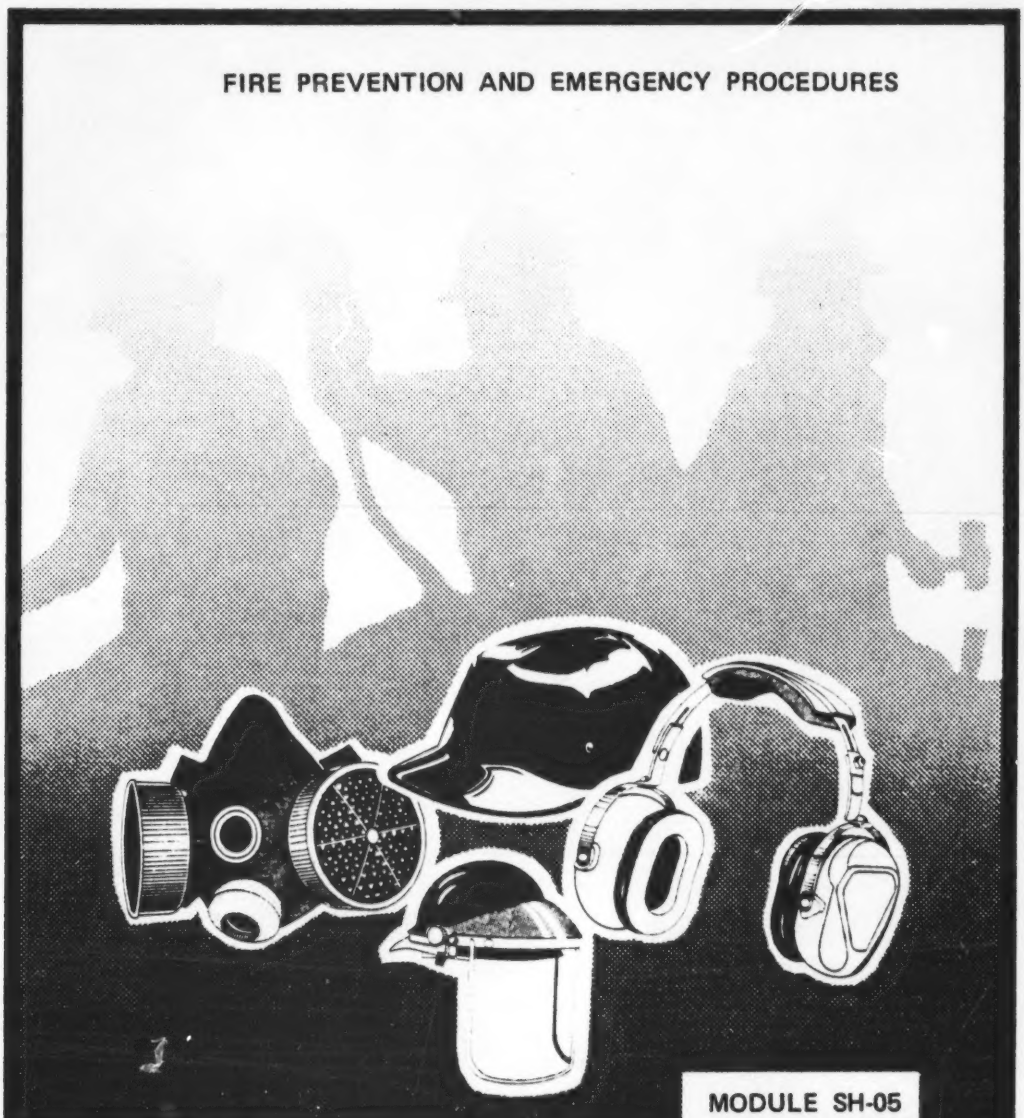
SAFETY AND HEALTH

FIRE PREVENTION AND EMERGENCY PROCEDURES



MODULE SH-05

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INTRODUCTION

"An ounce of prevention is worth a pound of cure" is an old saying that applies to fire as well as to illness. Fire prevention is far less costly than the "cure" of fighting a fire. When industrial fires do occur, they take a very heavy toll. Lives may be lost; workers may be injured; property may be damaged or destroyed; productivity may be halted or reduced; and jobs may be threatened or abolished.

Fire prevention can be accomplished through an understanding of the chemistry and the causes of fires. Employees need to be trained in hazard recognition and safe work habits that will minimize the risk of fire.

When fires are not prevented, early detection and action can save lives and millions of dollars. Fire detection and alarm systems involve the use of mechanical devices as well as human ability to sense fire and sound the warning. Emergency action procedures are a key aspect of preparedness. They should be planned by the employer and learned and practiced by all employees. Controlling or extinguishing fires requires regularly maintained extinguishers, including standpipe or sprinkler systems. In some high-risk industries, a group of highly trained firefighters will be part of the fire protection strategy.

This module addresses fire prevention and emergency procedures. The chemistry of fire and the methods for extinguishment are discussed, along with the steps necessary for emergency action.

OBJECTIVES

Upon completion of this module, the student should be able to:

1. List the basic requirements for an emergency action plan. (Page 3)
2. List and discuss the points that should be included in any fire prevention plan. (Page 5)
3. State the two kinds of fire-fighting activities that may be performed by fire brigade members. (Page 7)
4. Describe the conditions that can give way to spontaneous combustion. (Page 8)

5. Describe the chemistry of fire. (Page 10)
6. List and give examples of the major causes of industrial fires. (Page 11)
7. Contrast "noncombustible" and "fire-resistive" construction. (Page 14)
8. Compare standpipe and automatic sprinkler extinguishing systems. (Page 16)
9. Compare portable fire extinguishers for specific classes of fires. (Page 20)
10. Briefly describe the characteristics of the following fire protection systems:
    a. Water Spray.
    b. Carbon Dioxide.
    c. Dry Chemical.
    d. Foam.
    e. Halogenated.

    (Page 21)

OBJECTIVE 1: List the basic requirements for an emergency action plan.

Every business or industry must have an emergency action plan in case of a fire or similar crisis. Employers have three choices for such a plan; they may (1) have all workers evacuate (leave) the building immediately, (2) train a small group of people to fight the fire while the rest evacuate, (3) train all employees in fire protection and fire fighting. Whatever plan is chosen, the emergency action plan and fire prevention plan must be in writing if the employer has more than ten employees. All employees need to know how to get out of the building or disaster area; therefore, any emergency action plan must satisfy this need. The plan must be reviewed with the employees yearly, at the very least. (See Figure 1.) If some or all of the employees are supposed to take an active part in fire fighting, in emergency actions such as shutting off utilities, inspection of equipment, or in the safe evacuation of others, then more frequent training will probably be needed to make sure that these key employees know what they are doing.

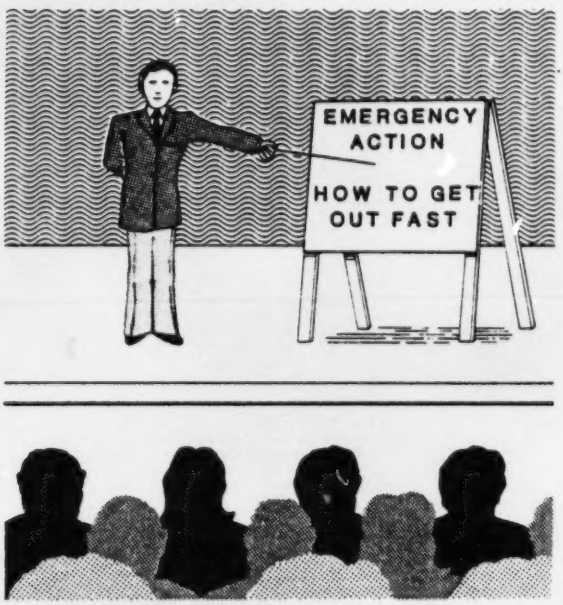


Figure 1. The emergency action plan must be reviewed with all employees.

Every emergency action plan should include the following:

- Planned escape routes and actions.
- A way to account for all employees once evacuation has taken place.
- Assigned rescue and medical duties if there are employees trained for and able to carry out those duties.
- The way the fire is to be reported (to the fire department and to other employees).

- The names of key employees in the plan — those who can give other people information about it.

The alarm used to warn workers of fire or other emergencies should be a signal known to everyone on the job and easily seen or heard above surrounding noise or light levels. A "buddy system" should be used to alert workers who cannot perceive light or sound systems due to a handicap or the kind of work they are doing. "Tactile" (relating to people's sense of touch) systems may also be used. Whatever kind of alarm system is used, it must be kept in working order at all times.

The purpose of the alarm system is to give the signal to evacuate the building, or to take emergency action if that is called for by the action plan. If the alarm system does not also notify the fire department or other emergency help, then employees need to be told the best way to call for outside help. Emergency telephone numbers should be posted near telephones.

ACTIVITY 1:*

List the three choices that employers have on which to base their emergency action plan.

1. _____
2. _____
3. _____

List five things that should be included in every emergency action plan.

1. _____
   _____
2. _____
   _____
3. _____
   _____
4. _____
   _____
5. _____
   _____

*Answers to Activities begin on page 24.

OBJECTIVE 2: List and discuss the points that should be included in any fire prevention plan.

Fire prevention must be the joint effort of management and workers. The employer is responsible for making a written plan for fire prevention. (If there are ten or fewer than ten employees, the employer may simply tell the employees about the plan.)

An effective fire prevention program deals first with the causes of fire. A list of workplace fire hazards should be drawn up, then proper storage and handling procedures for those hazards should be decided. Potential ignition sources (possible fire starters such as welding or smoking) should be identified (see Figure 2), and ways should be found to remove or control those sources. Housekeeping practices should be included in the plan; especially important are ways to keep flammable and combustible materials from building up in the workplace. Good maintenance programs for all heat-producing equipment can prevent electrical problems that sometimes cause fires.

Figure 2. Potential ignition sources.

Fire detection and fire-fighting equipment must be chosen carefully to fit the building or plant where they are to be used. There is no one system to fit every industry or situation. Fire detectors are now available that can reduce detection time to hours in the case of smoldering fires and to a fraction of a second in explosion-risk areas. Fire-fighting equipment includes sprinkler systems, fire hoses, fixed and portable extinguishers and other devices. All equipment must be inspected regularly to see that it is working properly. Employees may need to be trained in the location of fire protection devices and in the way such devices operate, since even the best systems are usually subject to human error. For example, ninety percent of sprinkler system failures are due to the system being turned

off. Education programs should stress that employees report any system that they find is closed.

Usually the many duties written into a fire prevention plan will be assigned to a number of different people. The inspection of the prevention equipment is usually delegated to supervisors. Because of the knowledge of the specific work practices, supervisors are in an excellent position to determine needed fire prevention measures within their departments. Inspection requirements will be covered later on in the module as individual fire-fighting systems are discussed.

Fire prevention education must be an on-going program, and management usually delegates this responsibility to a plant fire manager or line supervisor. Training of employees for a fire brigade, if the company chooses to form one, is discussed in OBJECTIVE 3. The key employees in any fire protection plan should be known to everyone, so that they can provide information about the plan to other workers.

The following list of questions may help workers to determine if their workplace is protected against fire and prepared for a fire or other emergency:

1. What are the fire hazards in the workplace (combustible materials, paper and cloth storage) and what has been done to control them?
2. What are the potential ignition sources (welding, smoking, electrical equipment) and what has been done to control them?
3. How would a fire be detected and reported to employees and professional firefighters?
4. How are people supposed to leave the building and how will they be accounted for when they get out?
5. Who is responsible for shutting down utilities or equipment before leaving the building?
6. What plans have been made for rescue actions and medical services?
7. What kind of equipment has been installed to control or fight the fire? Who is in charge of inspecting this equipment?
8. Who would actually fight a fire and how are these people trained for that job?
9. How can employees find out about the fire prevention and protection plan and the emergency action plan?

ACTIVITY 2:

1. List five things which should be considered in a fire prevention plan.
   a. _____
   b. _____
   c. _____
   d. _____
   e. _____
2. List three questions a worker should ask to find out if his workplace is well protected in case of fire or other emergency.
   a. _____
   b. _____
   c. _____

OBJECTIVE 3: State the two kinds of fire-fighting activities that may be performed by fire brigade members.

If an employer decides to form a fire brigade within the plant, there are two different kinds of fire-fighting activities to consider:

- Fire brigade members may be expected to control or put out fires that are in very early stages. Members of this kind of brigade should be trained in the use of fire extinguishers, standpipes, and hoses, as well as first aid procedures for the injuries that may result from fighting a fire. Such training must include classroom and "hands-on" experience.
- Some fire brigade members may be expected to perform emergency rescues and fight interior structural fires. (Interior structural fires affect the inside walls and basic support of the building.) The requirements, training, and personal protective equipment for this group must be greater than for the early-stage firefighters.

If the company organizes its own employee fire brigade, then the areas of the plant and the duties for which each employee is responsible during a fire, should be clearly assigned. It is very easy to become confused in a stress situation, and thorough training and education are essential for the industrial fire brigade. This training should take place at least once a year for "early stage" firefighters. Those fire brigade members who are

expected to fight interior structural fires should have an education or training session at least every three months. Sometimes training is held during two or three weeks of plant shutdown each year, and refresher sessions may be given more often.

Fire brigade members who are going to fight fires which affect the interior structure of the building, (that is, the interior walls, ceilings, beams and so on) rather than the contents of the building only, must meet certain physical requirements. A physical fitness program is recommended for them, and an employer should not allow anyone with known heart disease, epilepsy, or emphysema to be a member of the fire brigade without a doctor's permission.

Personal protective equipment (fire-resistant coats, gloves, and so forth) should be provided to all employees who fight interior structural fires. Such equipment should include protection for the head, body, legs, feet, hands, arms, eyes and face.

ACTIVITY 3:

State three things an "early stage" firefighter should be trained in:

1. _____
2. _____
3. _____

and two extra provisions an employer should make for those trained to fight fires inside the structure.

1. _____
2. _____

OBJECTIVE 4: Describe the conditions that can give way to spontaneous combustion.

Combustion and oxidation are terms that must be understood in any discussion of fire. Oxidation occurs when a substance "takes on" oxygen in a chemical reaction. Slow oxidation occurs in many different situations where oxygen is present. Slow oxidation may lead to spontaneous combustion, or fire. Spontaneous means self-starting. Combustion is a chemical change in which

oxidation takes place very rapidly, so rapidly that noticeable heat and light are produced.

For example, oily rags ledt in a closet may suddenly burst into flame and cause a dangerous fire. The oil in the rags oxidizes slowly; if the heat of slow oxidation cannot escape, the temperature of the rags rises higher and higher. Finally the oil and rags reach what is called ignition temperature, the temperature at which they will burst into flame. Combustion that occurs in this way is known as spontaneous combustion.

Spontaneous combustion is most likely to occur in poorly ventilated areas where large quantities of organic materials, or bulk materials soaked with oils, are stored. If these materials are packed loosely, leaving a large amount of surface open to air, then oxidation can occur. If the area is poorly ventilated, then the heat produced by slow oxidation will not be carried away. The heat will build up, eventually starting a fire.

The best way to prevent spontaneous combustion is to keep all oxygen (the air is 21% oxygen) away from combustible materials so that oxidation will not occur. Materials such as paint- and oil-soaked rags should be stored in tightly closed metal containers. Spontaneous combustion may also be prevented by (1) ensuring adequate ventilation, (2) removing external sources of heat, and (3) storing materials in smaller quantities in approved safety containers.

ACTIVITY 4:

Fill in the blanks.

_____ occurs when a substance "takes on" oxygen in a chemical reaction. Slow _____ may lead to spontaneous _____. Spontaneous means _____.

Spontaneous _____ is most likely to occur in _____ _____ areas where large quantities of _____ materials, or bulk materials soaked with _____, are stored. If these materials are packed loosely, leaving a large amount of surface _____ ____ ____ ____, then oxidation and subsequent spontaneous _____ will eventually occur.

The best way to prevent spontaneous _____ is to keep all _____ away from combustible materials so that _____ will not occur.

OBJECTIVE 5: Describe the chemistry of fire.

Fire prevention and control should begin with an understanding of basic fire chemistry. When a substance that will burn is heated to its ignition temperature, it will continue to burn as long as there is fuel, proper temperature, and a supply of oxygen. These combine to produce a chain reaction that is normally called a fire pyramid (or tetrahedron). Therefore, the four basic components of a fire are heat, oxygen, fuel, and chain reaction (Figure 3). Remove any one component and the fire goes out. If this process takes place in a confined space, an explosion may result.

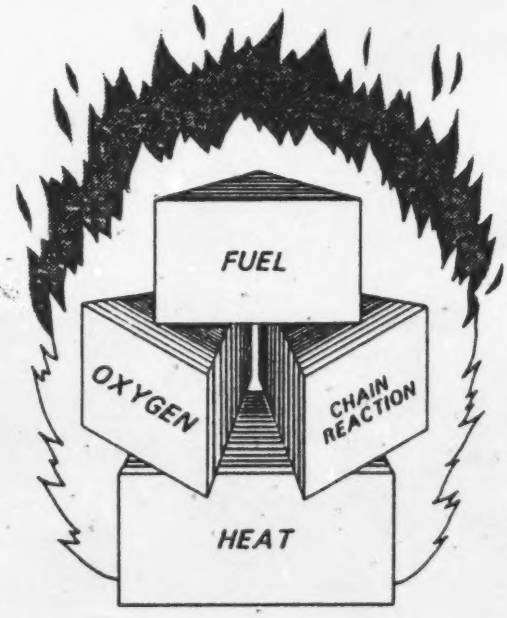


Figure 3. Four basic components of a fire.

Fires can be extinguished or controlled by removing or inhibiting (holding in check) any one of these four components: heat, oxygen, fuel, and chain reaction. Heat can be taken away by cooling; oxygen can be removed by shutting out the air. Fuel can be removed to an area where there is insufficient heat for ignition, and the chemical reaction can be stopped by inhibiting the rapid oxidation of the fuel.

The most common way to extinguish a fire by cooling is to apply a water spray. More heat is required to vaporize water than to vaporize other extinguishing agents. When water is vaporized (made into steam) it expands 1700 times. The water vapor reduces the amount of oxygen available to feed the flame.

Extinguishing a fire by removing oxygen can be accomplished by smothering the burning area with a noncombustible material, such as a wet blanket, dirt, sand, or a dry chemical extinguishing agent.

Removing fuel from a fire is usually a difficult and dangerous procedure; however, there are a few exceptions. If a flammable gas should catch fire as it flows through a pipe, that fire can be extinguished by shutting off the fuel supply. Flammable liquid storage tanks can be arranged so their contents can be pumped into a diked area (an area set apart by a wall of dirt or stone.)

Interrupting the chemical chain reaction of the fire is accomplished by using dry chemicals such as sodium and potassium bicarbonate base and ammonium phosphate base agents.

ACTIVITY 5:

List the four components of a fire pyramid and list one way in which each component can be removed or extinguished.

1. _____
2. _____
3. _____
4. _____

OBJECTIVE 6: List and give examples of the major causes of industrial fires.

Fire prevention can be accomplished through an understanding of the causes of fires. The Associated Factory Mutual Fire Insurance Company recently made a study of more than 25,000 industrial fires that took place over a ten-year period. The reported causes of ignition in these fires are given below.

Electrical ignition is the leading cause of industrial fires, accounting for 23 percent of all industrial fires. Most of these fires start in electrical wiring and motors. Overheated electrical equipment and arcs from short circuits in improperly installed and maintained electrical equipment are two of the leading causes of ignition. Only equipment that is approved by a national testing laboratory (such as Underwriters Laboratories) for use in hazardous locations, should be used where flammable gases or vapors may be present. Temporary or makeshift wiring, especially if it is faulty or overloaded, is an outstanding cause of electrical fires. Portable electric tools

and extension cords should be inspected at frequent intervals and repaired immediately, if repair is needed. All electrical equipment, particularly portable power tools, should be grounded or double insulated to protect the operator. Employees should be taught the proper use of electrical equipment and should never tamper with electrical equipment without authority.

Smoking is the cause of 18 percent of the fires that occur in industry. Carelessly discarded cigarettes, pipe embers, and cigars are a major source of fires. It would be extremely difficult to completely eliminate smoking in a plant. However, smoking should be allowed only in designated areas. Smoking should be prohibited in woodworking shops, textile mills, flour mills, grain elevators, and places where flammable or combustible products are manufactured, stored, or used (Figure 4). "No Smoking" areas should be marked with conspicuous signs.

In a large automobile manufacturing plant, several warehouse employees frequently took breaks in "secret rest areas" made of cardboard and plywood that were built into the bottom of storage tiers. When a careless worker left a burning cigarette in one of these nooks, the combustible plastic instrument panels nearby caught on fire. In this case, breaking the "no smoking" rule resulted in 18 acres of charred merchandise, $200 million in direct losses, and $50 million in business interruption loss.

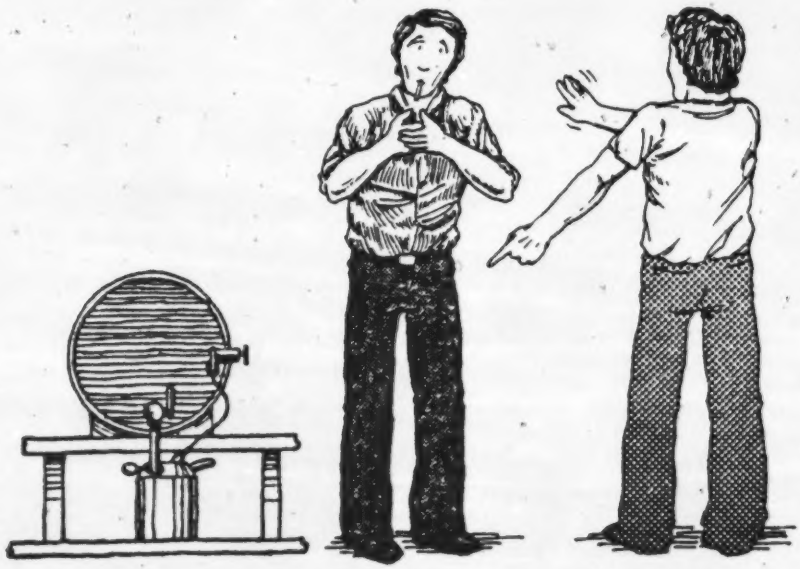


Figure 4. Smoking should be prohibited where flammable or combustible materials are used.

Friction is the cause of ten percent of all industrial fires. Fires frequently result from overheated power transmission bearings and shafting in buildings where dust and lint accumulate. (Build-up of dusts occurs in grain elevators, cereal, textile, and woodworking mills, and in plastic and metal-working plants.) On belt-driven machinery where the belt is too tight or too loose, friction can cause overheating which may result in a fire. Frequent inspections should be made to ensure that bearings are kept well lubricated and do not "run hot." Any accumulation of flammable dust or lint on bearings should be kept to a minimum. Drip pans should be provided beneath bearings and should be cleaned frequently to prevent oil from dripping on the floor or on combustible materials below. The overall key to friction control is to have a good program of preventive maintenance on plant machinery.

Open flames are probably the most obvious source of ignition for ordinary combustibles, and one would think they could be most easily avoided. In fact, open flames account for seven percent of industrial fires. Heating equipment, torches, and welding and cutting operations are principal sources of open flames. Heating equipment is commonly used on construction sites and it often causes fires because people fail to insulate heaters from floors or other combustible bases. Heaters are often not provided with a good spark shield, and the use of incorrect fuel causes fires. Torches using gasoline, kerosene, or alcohol as a fuel should be placed so that the flames are at least 18 inches from wood surfaces. Torches should not be used around flammable liquids, paper, excelsior, or similar material.

When possible, welding and cutting should be done in special fire safe areas or rooms with concrete or metal plate floors. In cases where welding and cutting operations are performed outside the special fire safe area, "Hot Work" permits should be obtained. A "Hot Work" permit is a form or tag that has been signed by the supervisor to show that certain precautions have been taken. Some of the typical precautions that might be required for a "Hot Work" permit are listed here:

- Inspect area where work is to be done.
- Set up a fire watch.
- Provide fire extinguisher equipment.
- Communicate to all departments concerned that "Hot Work" will be going on.

- Isolate combustibles from sources of ignition.
- Limit unauthorized use of flame- or spark-producing equipment.

Welding or cutting should not be permitted in or near rooms containing flammable liguid, vapor, or dust, nor in closed tanks or other containers which have held flammable liquids, until the containers have been thoroughly cleaned.

Some of the other causes of industrial fires are spontaneous combustion, molten substances, chemical sparks, static sparks, lightning, and arson.

ACTIVITY 6:

List four major causes of industrial plant fires and give two specific examples of each.

1. _____
2. _____
3. _____
4. _____

OBJECTIVE 7: Contrast "noncombustible" and "fire-resistive" construction.

When workers consider fire safety in the workplace, they are bound to give thought to the construction of the building in which they work. Few employees are in a position to control the design or selection of materials for a plant, but knowing about types of building construction leads to a greater understanding of fire hazards.

At the present time, building codes exist on the state and local levels. A building code regulates and controls building design, construction, materials, location, and occupancy (the use to which a building is put). The fire safety provisions in state and local codes are based on the standards published by the National Fire Protection Association (NFPA).

Both the building department and fire prevention bureau need qualified, experienced people to properly regulate all the aspects of life safety that can arise. All building codes recognize several types of building construction, each having a varying degree of fire resistance. Most building codes

classify five standard types of building construction:

- Fire-resistive (able to survive fires of a certain heat for a certain length of time).
- Heavy timber (load-bearing beams and walls are thick wood that withstand burning for a long period of time).
- Noncombustible (the structure will not burn, but is vulnerable to fire and may collapse).
- Ordinary construction (outside walls are noncombustible; inside walls are combustible).
- Wood frame (mostly wood).

The classification of building construction and building materials is based upon the number of hours that the materials can resist the effects of fire. Ratings may indicate one hour, two hours, or many hours of resistance to fire.

Fire-resistive construction requires that all structural members, such as walls, columns, floors, and roof construction are of noncombustible materials with a specified fire-resistance rating. (The term "fire-resistive" is sometimes mistakenly taken to mean "fire proof." Actually, "fire-resistive" describes a broad range of structural systems that can withstand fires of specified intensity and duration without failure.) Fire-resistive structures do not contribute fuel to a fire. However, combustible trim, ceilings, and other interior finish and furnishings can feed a fire and pose a serious threat to life safety. Attempts should be made to limit the amount of combustible material in a building, both in its construction and in its contents. This includes control of the use, handling, and storage of flammable and combustible liquids, gases, and solids.

In heavy timber construction, the load-bearing walls, columns, beams, and girders may be of wood. Heavy timber construction results in a slow-burning building. The wood timbers can burn, but because of their thickness (six to eight inches), they must be exposed to fire for a long period of time before structural collapse takes place.

Noncombustible structures include all types of construction in which the structure itself is noncombustible but not fire resistant. Examples are exposed steel beams and columns, masonry, and metal. Because of the tendency of steel to warp, buckle, and collapse under moderate fire exposure, noncombustible construction is best suited for business or manufacturing companies

in which the risk of fire from daily operations is very low. If quantities of combustible materials are present, the building should be protected with an automatic sprinkler system.

Ordinary construction consists of masonry exterior bearing walls that are of noncombustible construction. Interior framing, floors, and roofs are made of wood or other combustible materials whose "bulk" is less than that required for heavy timber construction. This type of building dominates in congested areas of large cities. Only businesses in which the fire hazards are moderate should occupy these structures. The use of highly combustible interior finishes (paints, wallpapers) should be avoided, where possible.

Wood frame construction consists primarily of wood exterior walls, partitions, floors, and roofs. Exterior walls may be sheathed with brick veneer, stucco, metal clad, cement-asbestos, or asphalt siding. The wood frame construction is generally considered inferior to other types of construction from a fire safety standpoint. Wood frame construction can be made reasonably safe for light-hazard occupancies through the use of noncombustible interior finishes, provision of exits, and other fire safety measures. Automatic sprinkler systems can greatly improve the overall fire safety outlook in wood frame construction.

ACTIVITY 7:

Fill in the blanks below with the five types of construction, in order of safety.

Offers most fire protection: 1. _____
2. _____
3. _____
4. _____
Offers least fire protection: 5. _____

OBJECTIVE 8: Compare standpipe and automatic sprinkler extinguishing systems.

No fire prevention program should rely on one type of protection. In addition to fire-resistive construction, emergency planning, preventive housekeeping, and other measures discussed in this module, equipment is needed

to extinguish and control fires. Included in this kind of equipment are standpipe and automatic sprinkler extinguishing systems.

An important aid to employees who are fighting a fire prior to the arrival of the fire department is a standpipe system. Fire standpipes are often installed in tall buildings, institutions, public assembly buildings, and other high-hazard locations. A standpipe is a riser water pipe within the structure, of a size determined by the estimated water flow needed. Standpipes are usually found in stairwells, or spaced over the floor area so that any given location is within 100 feet of the standpipe hose connection. Usually, a 1 1/2-inch hose line will be connected to the standpipe for first-line defense by the building occupants or private fire brigade members. The public fire department will bring its own 2 1/2-inch hoses to connect to the 2 1/2-inch ports on the riser.

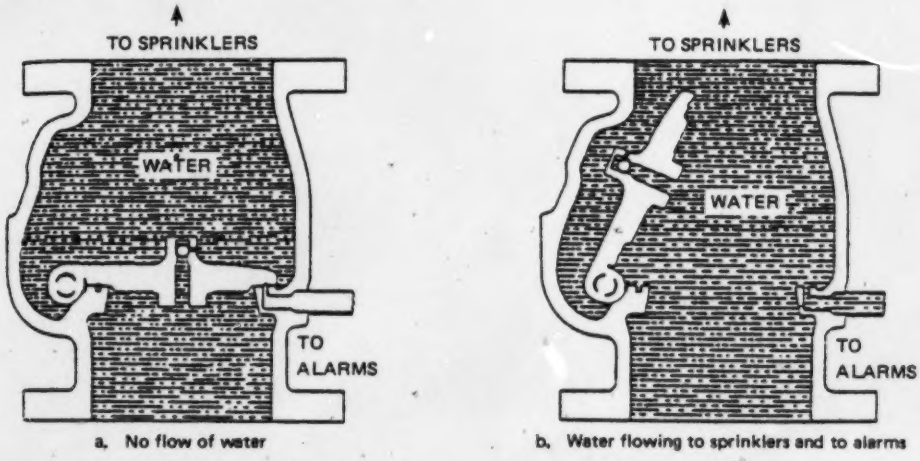
Normally, the standpipe system will be a wet-pipe system. That is, water will be available in the system at all times. In some rare cases, it will be a dry-pipe system, with no water available through the system until the fire department pump truck supplies it. The wet-pipe system is the preferred system and should be supplied by two independent sources of water.

The derived pressure from the water supply should be a minimum of 20 pounds per square inch (psi) at the highest outlet in the standpipe, and preferably 40 to 50 psi when the water is flowing. A supplementary supply of water to the standpipe should always be furnished by the fire department. Fire department pump trucks can supply water to the standpipe system by means of a connection at the base of the building. At least one such connection should be provided for each standpipe system.

An automatic sprinkler system is similar to a standpipe system in construction and supply. By means of a series of sprinkler heads, a sprinkler system is designed to automatically release water to extinguish a fire or to hold it in check until further aid can arrive. The sprinkler head is fed by a series of pipe lines graduated in size. Automatic sprinkler systems are credited with being the best counterattack against fire. In fact, sprinkler systems have an outstanding record of efficiency: In 96 percent of the fires in sprinklered buildings, the sprinkler has extinguished or controlled the fire. Most failures of sprinkler systems are due to human error rather than the system failure.

The sprinkler head is activated by heat and is designed to operate at varying temperatures dependent upon the normal temperature of the area to be protected. Normally, the area covered by one sprinkler head is 100 square feet in industrial areas. In offices, one sprinkler can cover up to 225 feet. The standard sprinkler head has a 1/2-inch discharge opening and must have a minimum pressure of seven to eight psi, with 15 psi being more desirable. At this pressure — 15 psi — the delivery rate of water in gallons per minute should be 22 gpm. Like the standpipe system, the automatic sprinkler system must have a good flow of water and it must come from a reliable source. Sprinkler systems come in various types that, in general, will fall within one of the four classifications listed here:

- The wet-pipe system (Figure 5) always contains water under pressure in the piping. The water will automatically flow when a head is opened, and water will be discharged immediately. The automatic alarm valve sets off a warning signal when water flows through the sprinkler piping.



a. No flow of water
b. Water flowing to sprinklers and to alarms

Figure 5. A wet-pipe sprinkler system.

- The dry-pipe system (Figure 6) is used where there is a danger of freezing. The piping contains air under pressure in place of water. If a head is opened, the air-pressure is released, causing a remote dry-pipe valve to open. This open valve permits water to enter the system and flow to the open heads. The dry-pipe system is slightly slower in getting water to the fire than a set-pipe system, but the pipes will not freeze and burst.

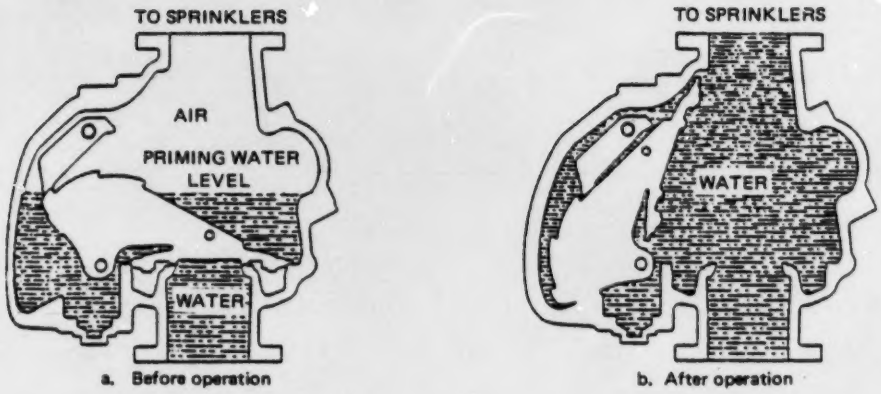


Figure 6. A dry-pipe system valve.

- A preaction system is designed to protect buildings from water damage if water should be released without fire. An added safety feature prevents water from being released through the open head or through faulty piping until a heat-detecting device is activated. This device opens a preaction valve controlling the flow of water.
- A deluge system has all sprinkler heads open at all times. The water is controlled by a deluge valve, similar to a preaction valve, which is activated by a heat-detection device. When this device is activated, there will be a "deluge" (rush of water) delivered to the area being protected. Generally, deluge systems are used in areas of greater-than-average hazard. Such areas may include explosives plants, lacquer plants, and buildings containing large amounts of flammable material.

Any given installation can have a combination of the various sprinkler systems, depending on how much protection is needed.

ACTIVITY 8:

Fill in the blanks.

1. The best sprinkler system to use in buildings where pipes could freeze would be _____.
2. A _____ sprinkler system has an added safety feature which prevents water being released by accident.
3. In a _____ system all sprinkler heads are open all the time.

OBJECTIVE 9: Compare portable fire extinguishers for specific classes of fires.

Portable fire extinguishers are used to supplement standpipe and sprinkler systems. Portable fire extinguishers can often preclude the action of the sprinkler systems because they can prevent a small fire from spreading.

"Portable" is the term applied to manually-operated equipment (equipment operated by hand) that is used on small fires. Usually portable extinguishers are used in the time between discovery of a fire and the functioning of automatic equipment or the arrival of professional firefighters. In order to be effective, portable fire extinguishers must be —

- Reliable (approved by a national testing laboratory).
- The proper type for each class of fire that may occur in the area.
- Sufficient in quantity to protect against the exposure in the area.
- Located where they are readily accessible for immediate use.
- Maintained in perfect operating condition, inspected visually on a monthly basis, and tested hydrostatically (to measure the pressure) once a year.

Portable fire extinguishers are classified to indicate their ability to control specific classes of fires. Labels on extinguishers indicate the class and relative size of fire that they are expected to control. In accordance with the National Fire Protection Association (NFPA) Standard No. 10, fire extinguishers are classified as follows:

Class A extinguishers contain water. They are used for fighting fires where paper, wood, or cloth (known as ordinary combustibles) are feeding the flames. The symbol for these extinguishers is a green triangle with the letter A on it. The number indicates the fire extinguishing capability of each unit. For example, a 4-A unit can be expected to extinguish approximately twice as much fire as a 2-A unit.

Class B extinguishers usually contain a dry chemical or carbon dioxide. They are used for fighting fires where flammable or combustible liquids, such as oil, paint, grease, or gasoline are feeding the flames. The symbol for these extinguishers is a blue square with the letter B on it. The number indicates the area in square feet. For example, a 10-B unit can be expected to extinguish 10 square feet of deep-layer flammable liquid fire.

Class C extinguishers contain a dry nonconductive chemical. These extinguishers are used to fight electrical fires, where electrical shock would be a hazard if water base extinguishers were used. A red circle with the letter C on it is the symbol for Class C extinguishers.

Class D extinguishers contain special extinguishing agents that can fight fires fed by combustible metals (magnesium, titanium). Class D extinguishers are symbolized by the letter D on a star. Persons working in areas where Class D fire hazards exist must be made aware of the dangers in using Class A, B, or C extinguishers on a Class D fire, as well as the correct way to extinguish Class D fires.

ACTIVITY 9:

While working at a refuel point, filling a 5-gallon safety can with gasoline, you accidently drop the 5-gallon can and the gasoling spills over the floor. In case of a possible fire outbreak, you quickly locate a row of various types of fire extinguishers. Which of the following do you choose? Circle the correct answer.

a. Class A extinguisher.
b. Class B extinguisher.
c. Class C extinguisher.
d. Class D extinguisher.

OBJECTIVE 10: Briefly describe the characteristics of the following fire protection systems:

Water Spray	Foam
Carbon Dioxide	Halogenated
Dry Chemical	

Any of the extinguishing agents mentioned previously can also be used in special fire protection systems. These sytems have the potential to bring the fire under control before the fire department arrives.

A water spray system is similar to a sprinkler system in that piping delivers water through a nozzle over and around a particular hazard. This system may be manual, having to be turned on when needed, or it may be fully automatic. This sytem is designed to protect flammable liquid or gas storage,

drum storage areas, large electrical transformers, and some explosive manufacturing processes. Because of its low electrical conductivity, water spray applied through fixed piping systems on electrical equipment with voltages as high as 345,000 volts has proved practical. Controlled burning rather than total extinguishment may be the goal of a water spray system. By keeping containers cooled against expansion and explosion, the fire can be controlled. There could be great danger of a further explosion if the leaking gas or liquid were extinguished and then lighted again by another source of ignition. In a situation where burning is controlled, it may be possible to shut off the supply of fuel or let the burning continue until the liquid or gas burns itself out.

An automatically activated carbon dioxide system (CO_2) has several advantages. Damage to equipment is minimal, because there is no liquid or solid residue. People can return to work promptly in areas where there has been no extensive damage. CO_2 has a low-cooling effect. In the case of extensive burning, it may be necessary to keep the room closed up and the inert atmosphere maintained until all danger has past. A CO_2 system is normally released in a sealed-off area so that the inert atmosphere remains.

CO_2 causes negligible damage as an extinguishing agent. For this reason it is used for vaults, computers, record rooms, and other places where the contents of the area have a high value. When the sytem is activated, the CO_2 quickly retards vision by forming a fog, and there is a danger in the oxygen deficiency of the atmosphere in the room. Because of this potential danger, the system has a warning signal. The signal will sound an alarm about 30 seconds before the system triggers itself, so that personnel can be evacuated and the room closed.

A dry chemical system is a rapid extinguishing system, extremely effective for surface fires and for use over flammable liquids, such as dip tanks, liquid storage, or liquid spill areas. Because it is nonconductive, the dry chemical system is useful for extinguishing fires in electrical equipment. However, this type of system can cause damage to delicate installations such as switchboards and computers. Extinguishing action results mainly from the interruption of the chemical, flame-chain reaction by the dry chemical agent.

Dry chemical extinguishing systems are growing in use in installations such as restaurants or cooking facilities. Such systems are used in the range hoods, in exhaust duct systems, and over deep-fat fryers.

A fixed-foam system is the ideal system for outdoor storage tanks. The system is designed to cover the entire floor area with foam, which may be either a mechanical or a chemical foam. The foam may be piped from a central foam house to the tank outlets, or the foam producing units may hook up to the tank discharge piping when a fire occurs.

Automatic halogenated systems are being used today in areas such as electronic data processing centers and record storage rooms where water-based systems are not desirable. In low concentrations (below 7%), halogen is a nontoxic agent. It is an odorless, colorless, nonconductive gas which extinguishes fires by breaking down the chemical reaction of fuel and oxygen. Halogenated systems are not effective against certain types of flammable materials such as:

- Fuels containing their own oxidizing agent, such as organic peroxides.
- Combustible metals, such as sodium, potassium, and magnesium.
- Metal hydroxides, such as lithium hydroxide.

Additionally, halogen has limited effectiveness on Class A fires when the halogenated agent is at a concentration below 10%. Also, halogen systems are extremely costly; the agent itself costs approximately ten times the cost of carbon dioxide (CO_2).

ACTIVITY 10:

State two facts about each of the following systems.

1. Water spray system.
   a. _____
   b. _____
2. Carbon dioxide system.
   a. _____
   b. _____
3. Dry chemical system.
   a. _____
   b. _____

4. Foam system.
   a. _____
   b. _____
5. Halogenated system.
   a. _____
   b. _____

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ANSWERS TO ACTIVITIES

ACTIVITY 1

1. To have all workers leave the building.
2. To train a small group of employees to fight the fire.
3. To train all workers in fire protection and fire fighting.

and

1. Planned escape routes and actions.
2. A way to account for all employees once evacuation has taken place.
3. Assigned rescue and medical duties.
4. The way the fire is to be reported.
5. The names of key employees in the plan.

ACTIVITY 2

1. a. Fire hazards.

   b. Potential ignition sources.

   c. Good housekeeping practices.

   d. Good maintenance programs.

   e. Good choice of equipment to prevent and fight fires.

2. Any three of the following.

   What are the hazards in the workplace and what has been done to control them?

   How is a fire to be detected and reported?

   How should people leave the area and how will they be accounted for after leaving?

   Who has to shut down utilities or equipment?

   What plans have been made for rescue actions and medical services?

   What kind of equipment is there to control or fight fire?

   Who inspects this equipment?

   Who would fight the fire and how have they been trained?

   How can workers find out about the fire prevention and emergency action plan?

ACTIVITY 3

Any three of the following:

Use of fire extinguishers; use of standpipes; use of hoses; first aid procedures for injuries they may meet in fighting fires.

and any two of the following:

Supply personal protective equipment; a test for physical fitness; a physical fitness program.

ACTIVITY 4

Oxidation; oxidation; combustion; self-starting.

Combustion; poorly ventilated; organic; open to the air; combustion.

Combustion; oxygen or air; oxidation.

ACTIVITY 5

1. Oxygen – smother with blanket, dirt, or sand.
2. Fuel – turn off valve, burn-out.
3. Heat – cooling with water.
4. Chain Reaction – dry chemicals.

ACTIVITY 6

1. Electrical ignition; overheated electrical equipment; arcs from short circuits.
2. Smoking; carelessly discarded cigarettes, cigars and pipe embers; smoking in a nondesignated area.
3. Friction; belts that are too loose or too tight on belt-driven machinery; an accumulation of dust or lint on bearings.
4. Any two — open flames; heating equipment; torches or welding and cutting operations; incorrect use of fuel; lack of spark shield or insulation.

ACTIVITY 7

1. Fire-resistive.
2. Heavy timber.
3. Noncombustible.
4. Ordinary.
5. Wood frame.

ACTIVITY 8

1. Dry-pipe system.
2. Preaction.
3. Deluge.

ACTIVITY 9

b. Class B extinguisher.

ACTIVITY 10

1. Any two of the following.

   Works like a sprinkler system; used to protect flammable liquid or gas storage; used to protect drum storage; used in some explosive manufacturing process; used on some large electrical transformers; controls fire, rather than extinguishing it.

2. Any two of the following.

   Causes little damage; used for high value rooms; clouds the vision; depletes the oxygen available for breathing; has a warning signal.

3. Any two of the following.

   Works very quickly; used for surface fires and over flammable liquids; is nonconductive; useful for electrical equipment; may damage computers or switchboards; interrupts the chemical, flame-chain reaction; used in restaurants or cooking facilities.

4. Any two of the following.

   Best system for outdoor storage tanks; covers entire floor area with foam; may be piped to the fire; units may be hooked up when a fire occurs.

5. Any two of the following.

   Used in areas such as electronic data processing centers; halogen is odorless, colorless and nonconductive; puts out fire by breaking down the chemical reaction of fuel and oxygen; cannot be used on certain types of flammable materials (organic peroxides, sodium, potassium, magnesium, lithium hydroxide); is nontoxic at concentrations of less than 7%; is very expensive; has a limited effect on Class A fires at below 10% concentration.